Note Title 09.10.2018

PG8405 - Modeling and simulation of production systems and well construction

Course plan

- Individual project
  - accounts for most of grade
  - deliverables:
    - report / paper format
    - all routines, computational files, simulation files
    - tentative: a powerpoint presentation
- common lectures on some topics
  - topics:
    - generalities about modeling in petroleum engineering
    - modeling of hydrocarbon production systems
      - well level
      - well + reservoir
      - component level
    - optimization

- model: numerical approximation of a real physical system
  - ↳ equation

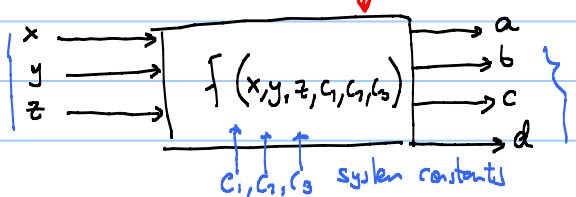
to make models I take into account equally first order effects.

models are derived from conservation principles
- make assumptions/simplifications
- steps:
  - apply conservation principles to control envelope
    - mass
    - momentum
    - energy conservation
  - obtain equations in differential form
  - discretize domain of interest
  - discretize equations
  - apply boundary conditions
  - solving discretized equations in an iterative manner

purpose
- prediction of future performance to define best control strategies ✓ production
- to evaluate the dependance between parameters
  - ↳ sensitivity studies
  - ↳ correlations

  use to design a system
  to troubleshoot a system
  to optimize a system
- improve the understanding of systems

models can usually be visualized as function



black-box models → no access to model details

white-box models → full access to model details

garbage in → garbage out

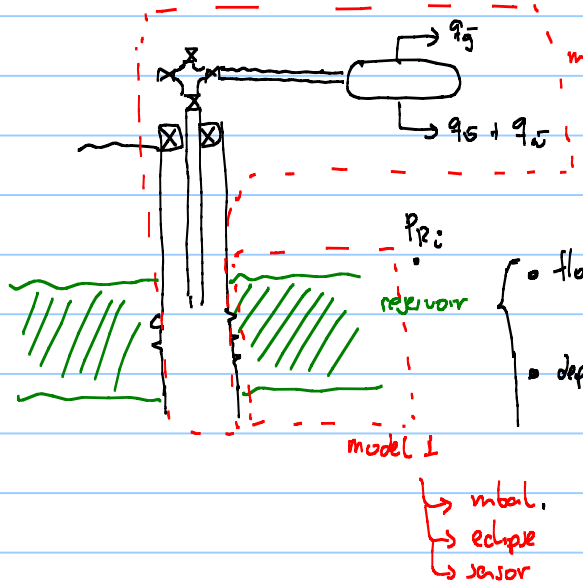
changes in system/operating conditions → model input is not usually a determinist number but rather a range, collection of values

model constants/parameters ⇒ " " " " " " " " " " "

uncertainty

Performance of production system: (reservoir + well)

- $q_o(t)$?
- $q_{H_2O}(t)$?
- $q_g(t)$?



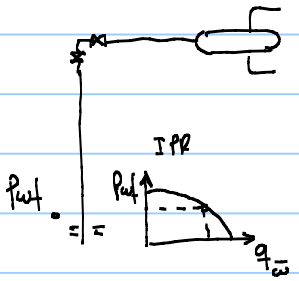
model 2 : pipesim
prosper + gap
pipeflow

- flow in porous media $\Delta p = f(q_g, q_o, q_{H_2O})$
- depletion performance (stability) change in time.

model 1
- mbal.
- eclipse
- sensor

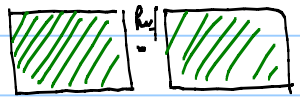
how do we couple these two models?

in pipesim

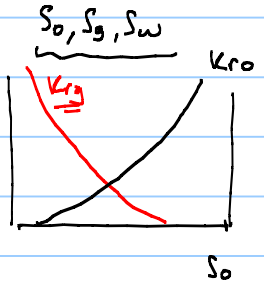


provides q_{H_2O}

requires $N_p = \int_0^t q_o \, dt$
G_p
G_{op}



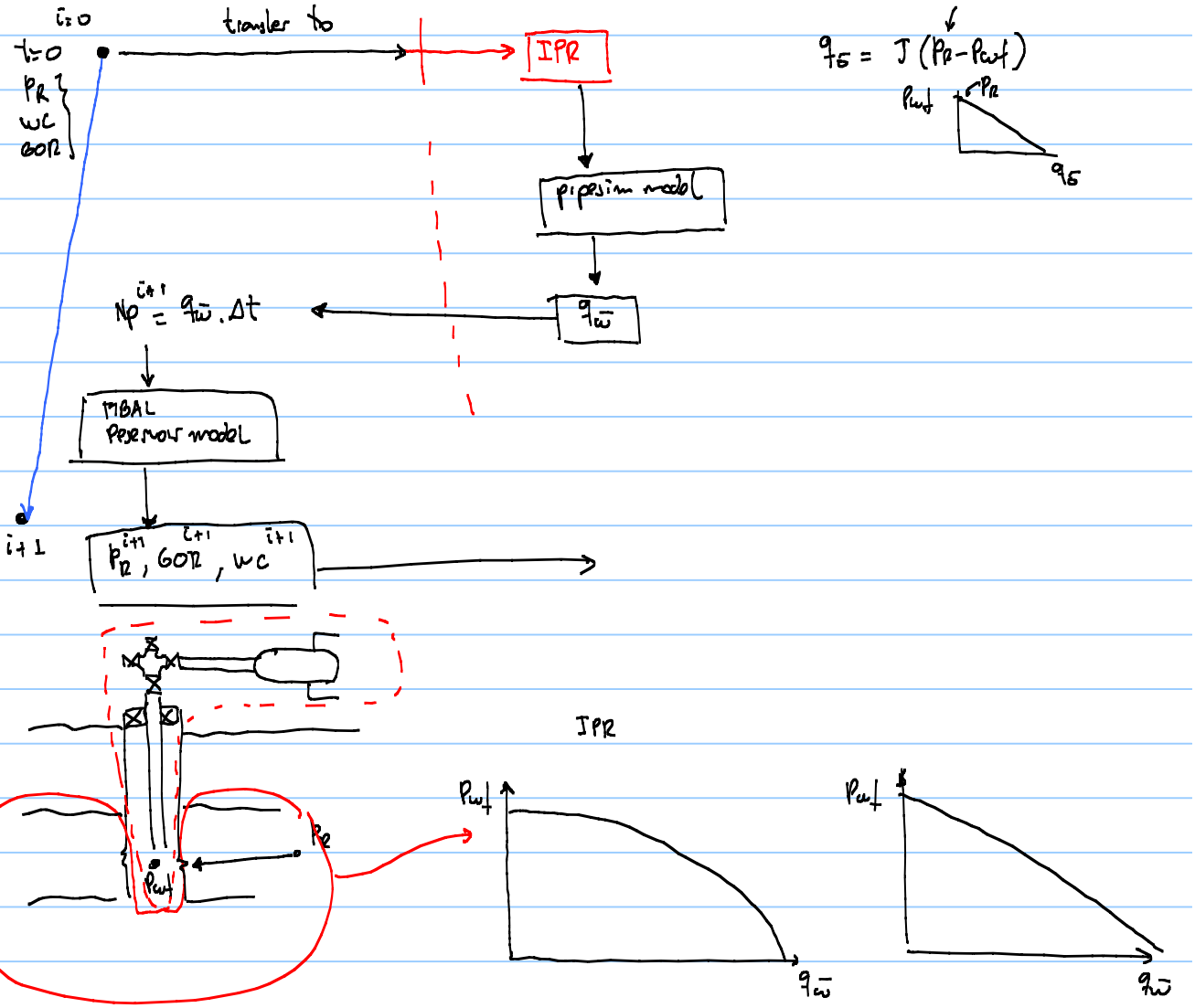
provides p_R

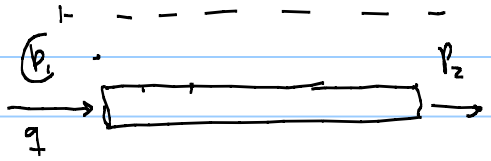


usually we can calculate GOR and WC

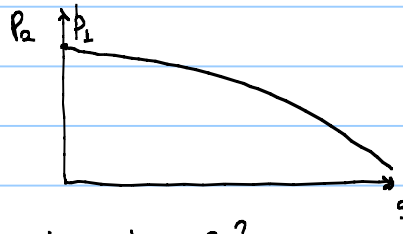
reservoir model

production system node



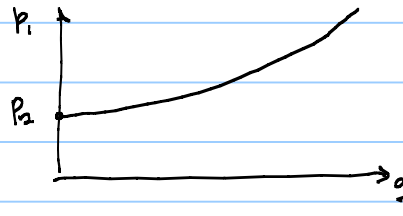


① p_1 is fixed, p_2 vs q?



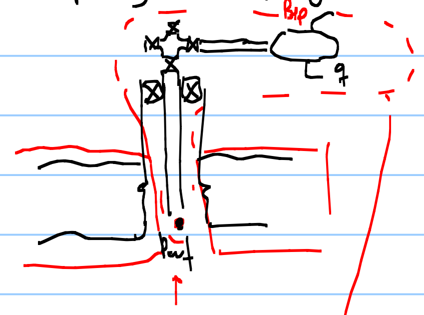
available pressure downstream of pipe
↳ co-current calculations

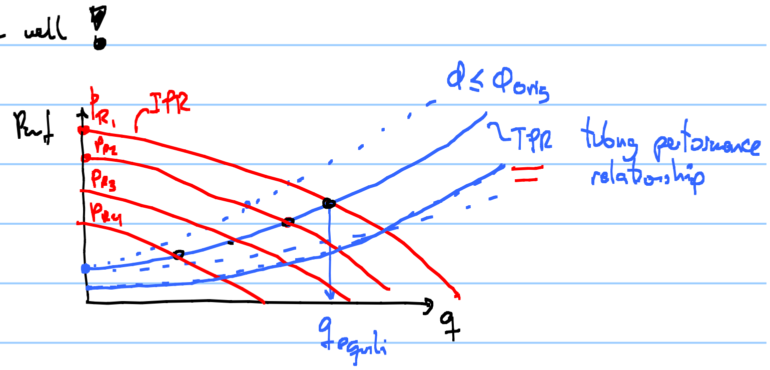
② p_2 is fixed, p_1 vs q?

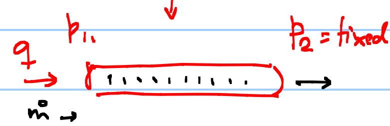


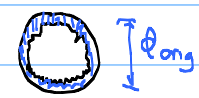
required pressure upstream the pipe
↳ counter current calculations

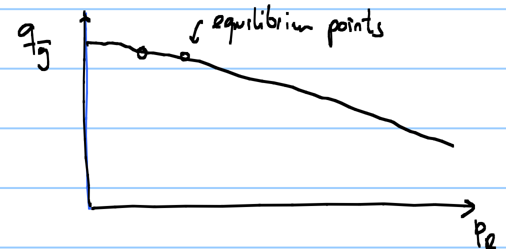
Find the operating rate of system reservoir + well !

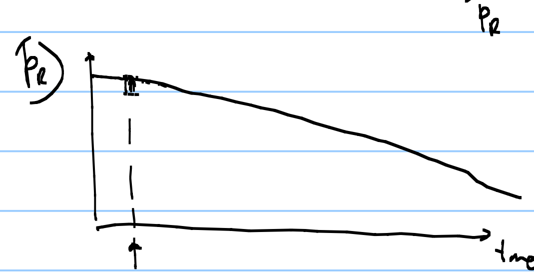












- home/class exercise flow equilibrium for gas well

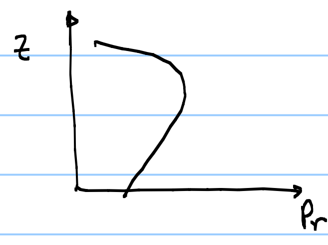
  → tubing

  → IPR

$$u = \frac{Q}{A} \qquad A = \frac{\pi \phi^2}{4}$$

$$Q = \frac{\dot{m}}{\rho}$$

$$z = f(P_r, T_r) \qquad T_r = \frac{T}{T_c}$$

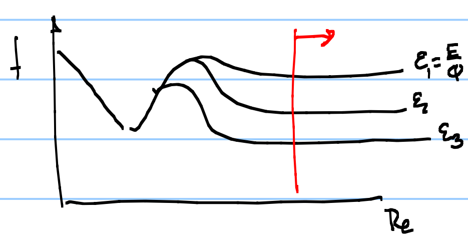


$$T_c = f(M_g)$$

$$T_{wf},\ T_{wh} \rightsquigarrow T_{av} = \frac{T_{wf} + T_{wh}}{2} \longrightarrow T_r = \frac{T_{av}}{T_c}$$

$$P_{wf},\ P_{wh} \rightsquigarrow P_{av} = \frac{P_{wf} + P_{wh}}{2} \longrightarrow P_r = \frac{P_{av}}{P_c}$$

$T_r,\ P_r \rightarrow z$



$$q_{\bar{g}} = C_R \left(P_R^2 - P_{wf}^2\right)^n$$ clear P_{wf} P_{wf} vs $q_{\bar{g}}$

$$P_{wf} = \sqrt{P_R^2 - \left(\frac{q_{\bar{g}}}{C_R}\right)^{1/n}} = f(q_{\bar{g}})$$

(-) if $P_R^2 < \left(\frac{q_{\bar{g}}}{C_R}\right)^{1/n}$ then $\sqrt{-}$ → error !!

try

$P_{wf} = f(q_{\bar{g}})$

exception handling capabilities

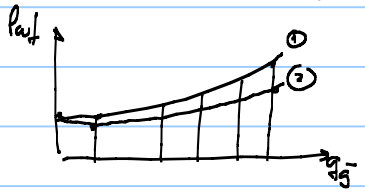
if exception

print message "the rate tried is too high"

homework 1: Calculate TPR → ① single C_T and S with $P_{in} = P_R$, $P_{out} = P_{sep}$

and compare

② several C_T and S with $P_{in} = P_{manif}$, $P_{out} = P_{sep}$



$$\varepsilon = \frac{\sum abs\left(P_{wf_{①}} - P_{wf_{②}}\right)}{\left(P_{wf_{②}}\right)} \cdot 100$$

homework 2: Calculate $q_{\bar{g}_{eq}}$ for P_R = 304, 290, 280, 270 ..... 100 bar